CARNEGIE INDIA

WORKING PAPER

JUNE 2023

The Geopolitics of the Semiconductor Industry and India's Place in It

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Introduction

For some time now, it has been almost conventional wisdom that states that trade with each other have less of an incentive to act with hostility toward each other. It was believed that economic interdependence would help prevent aggression.[1] This argument is being severely tested when it comes to relations between China and the United States. While the prospect of any military conflict between them is low, there has been an undeniable surge in tension in their trade relationship.

Rising tensions have set China and the United States on a gradual economic decoupling. The technology export-control measures that were unveiled by former U.S. president Donald Trump's administration in May 2019 and May 2020 have not been rolled back by the subsequent Joe Biden administration, and they have set both countries striving for self-sufficiency. Nowhere is this more evident than in the semiconductor industry.

The last few years have seen a pressing shortage of semiconductors, which matters greatly since the industries of the future will be heavily reliant on chips. Semiconductors will be critical to the foundational technologies of artificial intelligence (AI), 3D printing, the Internet of Things, and advanced robotics, and any shortage in them will hurt not only the economic prospects of technology companies but also of countries that hope to deploy such technology. Semiconductors have long been critical to the functioning of various industries, ranging from aerospace to automobiles. An estimate put the number of industries impacted by the recent global semiconductor shortage at 169.[2]

The shortage can be ascribed to various reasons. First, the onset of the COVID-19 pandemic led to most semiconductor foundries redirecting their supply to industries that saw an increase in demand for their products. Bringing back this supply to where it was at the start of the pandemic has been very challenging. Second, a series of disasters ranging from fires to earthquakes and droughts affected key supply-chain hubs and further exacerbated the shortage.[3] Third, Moore's Law, according to which the number of transistors in integrated circuits doubles roughly every two years, is now seen as taking longer to play out and even as possibly having become obsolete.[4] Last, and most significantly, export-control measures were initiated by the Trump administration in 2019 to prohibit the supply of certain semiconductor technologies to proscribed Chinese entities, and these measures were further tightened in 2020. However, before the export-control measures took effect, Chinese entities stockpiled a massive number of semiconductor technologies and machinery, worsening the shortage.

The U.S. export-control measures are likely to be the most enduring reason for semiconductor supply chains undergoing a significant restructuring in the coming years. The pandemic continues to subside and the use of specialized hardware to speed up processing power has extended the relevance of Moore's Law into the near future,[5] but the U.S. measures are unlikely to be withdrawn. What is more, the Biden administration is reportedly considering further measures to ensure that even mature and older semiconductor design technologies do not end up in Chinese hands.[6] Given the severity of these measures, a gradual decoupling between China and the United States in various spheres looks to be in the offing. However, while a technological decoupling seems to be underway, predicting how it will unfold is fraught with uncertainty, given that the evolution of most technologies is not linear.[7]

At a time when almost all major countries are seeking to build self-sufficiency in their supply chains, an excessive focus on doing so risks building inward-looking supply chains that do not interact with each other or supply chains containing bubbles that are not interoperable. And if there are different product specifications and components that are not interoperable, the process of setting standards will become even more critical and the next battleground in the quest for technological dominance.[8] Standard setting in semiconductors is currently a competition between China, Europe, and the United States, with none enjoying unquestioned dominance.

This paper looks at the key reasons for the semiconductor shortage and highlights how the U.S. export-control measures were shaped by a variety of security, trade, and economic factors. It then looks at whether this is part of a larger, lasting technological decoupling between China and the United States—different from the fragmentation of supply chains in the semiconductor industry in the 1980s—and, if so, how this may impact standard-setting initiatives. Last, it looks at how others, including India, may fit in a world with distinct tech blocs.

The Shortage of Chips

Following the onset of the COVID-19 pandemic, the automobile industry suffered the crippling effects of a shortage in semiconductors. The concentrated nature of the semiconductor supply chain further exacerbated matters since there were no alternatives to the usual suppliers. There were several causes for the shortage.

First, the pandemic led to a sudden albeit momentary disruption in global supply chains for almost all products and services. The semiconductor industry was no exception. For instance, due to a nosedive in automobile sales, many automobile companies had to cancel orders or to invoke provisions in their order contracts to halt the supply of semiconductors.[9] Meanwhile, the key foundries redirected their supply of semiconductors to other industries such as consumer electronics and cloud computing, which witnessed a surge in demand as work-from-home became a normal practice.

Second, a series of disasters restricted the supply of semiconductors. A massive earthquake in Japan in February 2021 led to a substantial constriction in output.[10] A major fire in Japan at one of the biggest factories of Renesas reduced the ability of this prominent chip supplier to fulfill orders to automakers worldwide.[11] Lastly, a drought in Taiwan prompted it to cut water supply to a major chip making hub, Taichung, as it directed manufacturers to conserve water that is normally used for industrial purposes.[12]

Third, the semiconductor industry is now realizing that Moore's Law has a limit. New estimates state that doubling the number of transistors in integrated circuits every two years or less would now cost eighteen times more in resources than it did in 1970.[13] Manufacturing semiconductors has become a highly capital-intensive and complex process, and capacity is an issue since quick upgrades are becoming harder to produce. On top of this, scholars have pointed out that the semiconductor industry is prone to other problems as well. These range from the rising costs of chip design to finding talent in an industry that has a very high-risk and high-reward nature.[14]

Last, the U.S. export-control measures of 2019 permitted sales of products that contained less than 25 percent of U.S-made content (later changed to 10 percent), and thus sales to Chinese entities continued. The United States then completely prohibited the sale of any product containing technology made by American companies to entities blacklisted by the Commerce Department.[15] Meanwhile, Chinese entities such as Huawei stockpiled goods and ordered several months', if not years', worth of semiconductors for products such as Xilinx's field-programmable gate arrays that Huawei uses for its base station technology.[16] Therefore, there was a massive surge in demand for chips before the pandemic, which exacerbated the ensuing chip shortage.

The U.S. export-control measures are implemented by the Department of Commerce's Bureau of Industry and Security (BIS). The BIS is responsible for ensuring that the Export Administration Regulations—the rules and laws that govern the export and reexport of commodities, software, and technologies ("items")—are implemented in a manner that advances national security, foreign policy, and economic objectives, including "continued U.S. strategic technology leadership."[17] Whether an item is controlled by the BIS usually depends on whether it appears on the Commerce Control List. Even if an item does not appear on this list, it could still require a license from the BIS.[18]

Chinese companies appearing on the Commerce Department's Restricted Entity List are barred from receiving U.S. exports, unless companies wanting to sell to them are granted an export license by the BIS. Such licenses are reportedly often granted.[19] However, with such sales to China coming under increasing scrutiny from the Biden administration, a tightening of the approval processes for licenses is likely.

Why Semiconductors?

The Trump administration did not originally envisage using export-control measures on semiconductors to extract leverage in its trade negotiations with China.[20] The negotiations were started to redress what the administration perceived as unfair trade practices by China and the massive trade deficit it ran against the United States. However, the discussions turned increasingly contentious with each side accusing the other of not negotiating in earnest.[21] The presence of China "hawks" in Trump's cabinet had led some in China to warn about the prospect of a trade war. For example, Pei Changchong, the director general of the Institute of Economics of Chinese Academy of Social Sciences, surmised that, given Trump's choice of cabinet officials, there was a high likelihood of trade friction with the United States.[22]

In March 2017, the Chinese telecommunications firm ZTE Corporation was fined $892 million after pleading guilty to violating U.S. sanctions law. In April 2018, it admitted that it had lied about complying with the terms of the settlement with the U.S. government, and the Department of Commerce immediately placed a ban on American companies on selling to the company.[23] ZTE was largely used as a bargaining chip in the trade war with China, and this ban was later removed. China saw this episode as another reminder that the United States did not want a trade deal, but rather to stifle its technological advance.[24] The Trump administration's May 2018 announcement that the United States would start proceedings to restrict Chinese investment and toughen export controls on Chinese purchases of

"industrially significant technology" did not counter that perception.[25] This was when China woke up to the reality that it could be cut off from supply chains for the cutting-edge components and equipment that would power the next generation of technologies. The trade war was officially turning into a technology war.

In June 2018, China offered to address the trade deficit and to boost imports of U.S. goods, especially semiconductors. The Trump administration was reportedly intrigued by the offer and even asked American high-tech executives what semiconductor products could be freed from export controls.[26] This shows that semiconductor technology was not yet at the heart of the dispute with China.

For some time, China's offer was considered a win-win. As recently as February 2019, the thinking in the Trump administration was that it should encourage China to buy more U.S. chips rather than cut it off from the ecosystem, which would encourage it to build its own semiconductor industry.[27] This was also thought to dovetail with the plan by China's top economic agency, announced that same month, to quintuple the value of semiconductor purchases from the United States to $200 billion over six years.[28] Although this was scaled down later to only doubling chip purchases, China's National Development and Reform Commission (NDRC) lobbied American semiconductor firms through the Semiconductor Industry Association (SIA) while the U.S. Department of Commerce considered implementing the deal. However, the deal never came to fruition, for two key reasons.

First, American firms rejected overtures from the NDRC to supply more semiconductors to China because this would have required a recalibration of their supply chains. This is because semiconductors count as exports to countries where they are assembled, which here refers to the process after fabrication where they are packaged in a container that follows a printed circuit board, appearing in a grid pattern.[29] This usually takes place in countries like Malaysia or Mexico before semiconductors are shipped to other countries like China to be sold as finished products.[30] In other words, the semiconductor sales proposed by the NDRC showing up as exports to China would have required relocating assembly, testing, marking, and packaging (ATMP) operations to the country. American firms did not consider this feasible since it would have meant substantial costs without generating additional revenue. The SIA members would have been able to service demand from China with supply chains being located where they currently were. As Sanjay Mehrotra, the CEO of Micron Technology, told then U.S. trade representative Robert Lighthizer, the industry wanted sales based on organic demand and not mere sales to the NDRC to prop up the market.[31]

Second, the SIA members were also against relocating ATMP operations to China as this would make them more dependent on the country, which could decide to cut off supplies in an emergency. U.S. semiconductor firms strongly wanted to prevent the creation of a chokepoint in the supply chain.

Besides the ban on sales to ZTE, there were other signs that the trade war was turning into a full-blown technological war. In May 2018, Lighthizer announced that tariffs, investment restrictions, and export regulations would be important to "protect our technology," and the abovementioned administration statement from the same month reiterated this message. In June, upon levying a 25 percent tariff on $50 billion of Chinese goods, Lighthizer said: "China's government is aggressively working to undermine America's high-tech industries and our economic leadership through unfair trade practices and industrial policies like 'Made in China 2025'."[32]

If there were any lingering doubts as to whether the Trump administration would use export controls on high-tech items such as semiconductors, these were laid to rest when the Department of Commerce placed Huawei on its Restricted Entity List in May 2019. Getting caught in the geopolitical battle between China and the United States severely affected the company's commercial prospects. The lack of access to advanced U.S. semiconductors crippled its ability to power 5G base stations and cloud computing services as well as its research and development (R&D) activities.[33] As a result, Huawei reportedly laid off 70 percent of its R&D staff in Silicon Valley.[34] The ban firmly placed technology center stage in the trade war.

Traditionally, China had recruited American businesses as allies whenever it faced pressure from U.S. administrations to address trade practices or human rights concerns.[35] The calculation was that businesses needed China's market to grow and would not want to lose access. However, things were different this time, with American businesses no longer responding to Beijing's attempts to court them, something that China's leaders appeared to be ignorant of. Former treasury secretary Henry Paulson commented on American businesses turning from cheerleaders to critics of China, saying: "How can it be that those who know China best, work there, do business there, make money there, and have advocated for productive relations in the past, are among those now arguing for more confrontation?"[36]

American firms had come to believe that, after decades of dialogue, China's government was still complicit in helping Chinese firms commit intellectual property (IP) theft. But it was Beijing's heavy promotion of domestic firms that really pushed American businesses over the edge. China's Made in China (MIC) 2025 plan, unveiled in 2015, had laid out a roadmap to promote "indigenous innovation" and to reduce reliance on foreign technology. At first glance, it was like any other industrial policy. However, what antagonized American firms was its specific objectives. MIC 2025 targeted 70 percent market share for several sectors by 2025. Foreign firms figured that this might involve a massive increase in subsidies and IP theft.[37] In the United States, and in Europe, it was believed that MIC 2025 had crossed a line with its massive state funding of public research institutions to implement its objectives.[38] For American companies, the plan was a confirmation of their worst fears that earlier sporadic or one-off unfair trade practices would become the norm in certain sectors.

Rather than assess why the MIC 2025 plan was vehemently criticized in the United States, China doubled down on its strategy of courting or threatening American businesses, calculating that these firms would lobby lawmakers to ease the pressure on the country.[39] But the shift in the perception of China was broad-based and reflected attitudes across various segments of the American establishment. While the security establishment was seen as keener for a decoupling of the U.S. and Chinese economies,[40] other constituencies—such as the usually pro-China business community and the pro-trade officials in the White House[41]—had also had a change of heart. The Trump White House believed that "strategic engagement" had outlived its usefulness,[42] and trade officials like Lighthizer also believed that the United States should "stop being so passive."[43] Lighthizer said: "We should not assume that aggressive action on our part would automatically make the situation worse."[44]

Fragmentation by Default vs. Decoupling by Design

Going by the National Security Strategies from the Ronald Reagan administration to the Barack Obama administration, the United States had not before seen semiconductor supply chains as an issue of national security. While supply chains in general were accorded significance in the 1980s and early 1990s, that was in the context of ensuring that raw-material inputs in certain industries—such as stealth technology, anti-satellite systems, precision-guided munitions, and computer and software technology[45]—were stockpiled. Supply chains only became relevant again during the Trump administration.

The relative absence of mentions of semiconductor supply in successive National Security Strategies coincided with a period during which a large number of American manufacturing jobs were offshored to countries such as Japan, South Korea, and Taiwan. This happening in the absence of a national strategy to maintain an edge in semiconductor manufacturing could be called "fragmentation by default." Semiconductor supply chains were becoming increasingly globalized.

The globalization of semiconductor supply chains happened due to the ever-increasing costs for integrated device manufacturers (IDMs) to undertake the designing and the fabrication of chips. The outsourcing of fabrication activities was all the more appealing due to the business model pioneered by Taiwan Semiconductor Manufacturing Company (TSMC). This new business model reflected the understanding that the prohibitive costs of doing everything would lead some IDMs to outsource chip fabrication to more cost-effective foundries. Other IDMs took note and increasingly offshored their fabrication to Taiwan

and other East Asian countries like South Korea.[46] This also coincided with the rise and spread of the idea of the globally integrated enterprise, which saw companies like Texas Instruments and IBM relocate their supply chains to East Asian countries like Japan in order to be close to semiconductor supply chains for accessing new components that were critical to their businesses.[47] Delayed access had severe commercial implications in the fast-moving consumer electronics market.[48]

Globalization had a lot going for it in the late 1980s and 1990s. The disintegration of the Soviet Union meant that Russia and various Eastern European nations were seen as "emerging economies." China was in the midst of a lengthy market-oriented reform process. And the spread of the internet meant that it was more feasible to coordinate complex supply-chain activities across geographies and time zones.[49] Therefore, a fundamental feature of globalization was the dispersion of supply chains to countries where it was most profitable to carry out activities.[50]

However, the globally integrated enterprise was largely a response to the political and economic forces[51] that at the time were devoid of economic nationalism.[52] More recently, though, disenchantment with business and political elites, amid halting global economic growth, has led to a resurgence of economic nationalism.[53] The central feature of this has been a renewed focus on secure and resilient supply chains, especially for semiconductors.

It is hard to pinpoint the exact moment when this drive for self-reliance became the focus of most countries' industrial policies. While the renewed emphasis put by the United States on semiconductors appears to have started with the institution of export controls on materials used for making them, China's shift in focus from consumer internet firms to more hard-tech companies was more abrupt and, therefore, more apparent. Both countries have started competing in a new race to be the central creator and purveyor of superior technologies, including semiconductors. While the measures to enhance the competitiveness of the American semiconductor industry, such as the Chips and Science Act of 2022, are recent, Intel and TSMC had earlier agreed to set up fab/foundries in Arizona.[54] China, for its part, has recently designed three industrial policies to pursue advanced semiconductor manufacturing: the Guidelines to Promote a National Integrated Circuit Industry, the MIC 2025 policy, and the Made in China 2025 Technical Area Roadmap.

China's leadership realized that the consumer internet economy, or the platform economy, which had served the country so well as the engine of growth after the 2008 global financial crisis, had run its course and that it was time to focus on areas where key technological breakthroughs would be needed. Then Chinese premier Li Keqiang in March 2021 identified semiconductors as a major priority area for hard-tech innovation.[55] This, along with the enforcement actions against the likes of Alibaba and Tencent in 2020 and 2021, was a massive transformation of China's approach.[56] In 2017, eight ministries issued a joint opinion to promote the "sharing economy." A light-touch approach to regulation ensued till 2020, when China's leadership suddenly changed track.[57]

This newfound focus on hard-tech does not appear to be a transitory phase. Data also bears out the concerns of Chinese policymakers. An often overlooked fact is that Huawei's total R&D expenditure in 2018 was more than that of Alibaba, Tencent, and Baidu combined.[58] The story is not very different for American firms. According to one study, even though total private R&D investment climbed from 0.7 percent of GDP in 1956 to 2.0 percent in 2014, most of that was for product development with only 20 percent of the R&D going to basic scientific research.[59] The brittleness of American supply chains has conveyed the message to the U.S. government that it will have to provide guidance for self-sufficiency in a way that the private sector has not been able to do. State intervention may be required, which may not be a bad thing for a country where the government incubated the chip industry in the first place. The obsession of American enterprises with efficiency and just-in-time supply chains may have been exposed as a mistake when it comes to critical technologies like advanced semiconductors. China, on the other hand, has traditionally placed greater emphasis on resilience as opposed to efficiency.[60]

When one looks at the global shift toward securing supply chains in critical technologies, along with the recent dip in global trade flows largely due to the U.S.-China trade war,[61] and the export-control measures cited above, what are we likely to see next? Recent decisions, some dating from the Obama administration, show that there has been a conscious decision to restore the United States' advanced semiconductor manufacturing capabilities, which had substantially withered during the era of "fragmentation by default." Given that semiconductor manufacturing capabilities have been set up in East Asia for decades, this will very likely disrupt the global supply chain. This time, the decoupling will be by design and not by default.

Possible Consequences of Export-Control Measures

The Geopolitics of Export-Control Measures

U.S administrations appear to have recognized that semiconductors were a strategic technology that needed to be protected prior to the 2019 export-control measures. The Obama administration thwarted attempts by Chinese firms to acquire American semiconductor companies. In 2016, Commerce Secretary Penny Pritzker labeled China's MIC 2025 plan as "designed to appropriate" the semiconductor industry.[62] She also claimed that China's industrial policy was governed by government interests rather than commercial objectives.[63]

However, the Obama administration dismissed export controls for semiconductor items because it expected such "unilateral action" to be "increasingly ineffective in a world where the semiconductor industry is globalized."[64]

At the end of the Trump administration's first year, export-control measures appeared to have fused into a larger policy aimed at a new way to engage with China. Three new strategic documents set out a more aggressive approach. The December 2017 National Security Strategy labeled China a "revisionist power."[65] The January 2018 National Defense Strategy identified "long-term strategic competition with China" as a "principal priority."[66] The January 2018 report of the U.S. trade representative to Congress on whether China had complied with the terms of its accession to the World Trade Organization (WTO) acknowledged that the "United States' approach to China is more aggressive than in the past."[67]

A key tool the United States has used to push this new approach is the Foreign Direct Product Rule (FDPR). This extends the jurisdictional reach of the Export Administration Regulations. The FDPR effectively regulates not only American items but also foreign ones as long as they are made using certain American technology and software. Companies that use key American technology to manufacture chips are thus required to apply for a license from the Department of Commerce, which faces a presumption of denial, before shipping any products made with this technology to any Chinese firms blacklisted by the department.

China experts had judged that there was a possibility the Biden administration would extend the FDPR rule to more, if not all, Chinese entities, and not just restrict it to Huawei and a few others.[68] A few members of Congress advocated this in 2021.[69] Still, the administration's swiftness in October 2022 in extending the FDPR to "Chinese buyers" and expanding its scope was unexpected.

That was the time when the Biden administration unveiled sweeping changes to its policy on export controls on semiconductors, among other items. A big reason for this is China's "civil-military fusion" strategy, which is predicated on the usage of private-sector technology for military and on commercial spin-offs of defense-related technology.[70] This fusion has made it harder for export controls to target China's military without affecting its commercial sector. With its new export-control measures, the United States has given up "trying to thread the needle" in this regard.[71] From now on, applications for export licenses to China for AI chips (including those for commercial use) above a certain performance threshold face a presumption of denial from the Department of Commerce. Outsourcing any manufacturing of AI chips to Chinese entities is prohibited.[72] Considering that some companies in China, such as Semiconductor Manufacturing International Corporation (SMIC) and Yangtze Memory Technologies Corp (YMTC) are already making such chips, the blocking of access to American software tools and semiconductor manufacturing equipment reveals a new pillar of U.S. strategy: it is no longer sufficient to keep China's semiconductor industry stagnating a generation or two behind that of the United States; rather, the United States will try to ensure that China's industry regresses.

Although the measures dealt with advanced AI chips with supercomputing applications, these were not categorized as "emerging and foundational technology" in the BIS document published in October 2022. Classifying them as such would have rendered it necessary for the BIS to issue an advance notice of proposed rulemaking and to seek public comments. Perhaps to sidestep this requirement and to prevent Chinese entities stockpiling such chips in China, the measures were declared applicable with almost immediate effect.

In summary, the October 2022 export-control measures:

- expand the applicability of these measures to all entities in China, not just those already on the BIS Restricted Entity List;
- are applicable with immediate effect to prevent stockpiling;
- are applicable to U.S. persons related to provision of items even when they cannot determine the precise end use of the items, in an attempt to curb civil-military fusion; and
- are unilateral.

There may be a further expansion of the FDPR rule down the road. The language used by the BIS so far in relation to Chinese entities such as SMIC specifies that the export of items that are "uniquely required to produce semiconductors at advanced technology nodes 10 nanometers or below will be subjected to a presumption of denial."[73] In early 2022, there was discussion within the Biden administration about a Department of Defense proposal to change the language from "uniquely required" to "capable of." The reasoning was that typically no semiconductor manufacturing equipment is designed specifically to produce a particular node. If such a change is accepted, it could subject a wider range of equipment to license denial.[74]

The Impact of Export-Control Measures

The U.S. export controls, including the stricter updates introduced by the Biden administration, have been a game-changer in how semiconductor companies the world over view China and whether the Chinese market will remain a viable long-term source of revenues. In particular, they may have the following impact:

i. Stoking China's modernization and indigenization efforts: China did not envision having a completely independent semiconductor technology stack. This is evident from its request to the Trump administration in May 2018 to drop its investigation under Section 301 of the Trade Act of 1974 and to give better treatment to Chinese technology companies, in particular ZTE, which was banned from purchasing American computer chips.[75] Seen together with the June 2018 offer by Beijing

to address the trade deficit by purchasing more American semiconductors, it is clear that China was not attempting to wean itself off American technology.[76] The export-control measures have changed that. China's drive toward modernization and the development of indigenous technology has accelerated. It is now estimated that nineteen of the world's twenty fastest-growing chip firms are Chinese.[77] This has, perhaps for the first time, also aligned the interests of Chinese firms with those of the Chinese Communist Party[78] when it comes to the self-sufficiency agenda announced by President Xi Jinping on the occasion of the party's hundredth anniversary in 2021.[79] China is also watching the sanctions that have been imposed against Russian entities and individuals in response to the invasion of Ukraine, even though these function more as an embargo, given the broad scope of their application. While self-sufficiency in a sector as complex as semiconductors may be a tall order, witnessing the full force of not just U.S. but EU sanctions against Russia may lead China to reinforce its efforts to integrate itself with a "non-U.S. supply chain."[80] This may be the case even if China may not be as badly affected by sanctions, given that it is a major trading partner of 130 countries, including many U.S. allies.[81]

ii. China's modernization efforts will face a challenge: The immediate impact of the export controls is the realization by China that its only option may be to build an indigenous semiconductor industry since it will not have access to cutting-edge machinery to fabricate leading-edge nodes. Funding should not be a worry given that its National Integrated Circuit Industry Investment Fund has so far raised $51 billion.[82] What makes things hard for China is the fact that the semiconductor industry is an iterative one that works best in a cluster. Companies in the semiconductor supply chain can share their infrastructure set-up, including R&D centers, talent pool, and manufacturing facilities. Many chip design firms prefer to be closer to chip fabrication facilities to enhance collaboration and iterate back and forth as much as possible to get the most out of the design process. Furthermore, having all major components of the supply chain in one place leads to shorter delivery times. Not being looped into this ecosystem would be challenging for China and hard to recreate.

iii. Unintended consequences: The supply chain for semiconductors is extremely convoluted, and the semiconductors shortage reinforced the point that more needed to be done to monitor supply chain disruptions. The Biden administration created the Supply Chain Disruptions Task Force to map the supply chain and to improve its transparency. The Commerce Department sent out requests for information to various companies at different stages of the supply chain. With more than 150 responses received, this revealed was that there was a considerable lack of transparency in the supply chain, even for those intricately involved in it. It showed that "producers don't always have a clear sense of demand, and chip consumers don't always know where the chips they need originate."[83] Another way of looking at this is that the export-control measures proposed effectively to ban a large number of Chinese buyers from purchasing semiconductors or semiconductor manufacturing tools and

equipment. Given that China imports $300 billion's worth of these, wiping out a substantial part of this sum could severely affect how global semiconductor firms operate and recoup their investments. Whether a sound cost-benefit analysis of these complexities has been undertaken remains unclear.

iv. Decoupling: While the term "decoupling" is generally used to cover the range of initiatives introduced by China and the United States to disentangle their economies and curb their dependence on each other,[84] here it is used with regard to semiconductors and the industries they impact, and to whether ending Chinese buyers' access to cutting-edge semiconductors and semiconductor manufacturing equipment could lead to a bifurcation between the tech ecosystems of China and the United States.

The shifting of supply chains is the first trend showing that a partial decoupling is underway. For instance, Samsung has announced that it will begin making semiconductor parts in Vietnam in July 2023 to diversify its manufacturing, given how China, the United States, and other nations are engaged in a race to secure their supply chains.[85] The Confederation of British Industry and Commerce has said that UK companies are "rethinking their supply chains" in a "world decoupled from China."[86]

The second could be a domino effect on the supply chains for other products and items that are not related to semiconductors. There have been reports that Chinese entities have been wary of purchasing even products that are not on the U.S. export-control list since they fear a creeping expansion of the measures to other industries.[87] In fact, the trade war and the tech export-control measures appear to work jointly toward a decoupling. American firms have held back from purchases from China of items subjected to U.S. tariffs. On the other hand, Chinese suppliers who do not know what future U.S. export-control measures to expect may self-correct by withholding purchases of American items. Regarding the former, recent data bears this out.[88] As to the latter, in July 2022 China recorded its first trade surplus with South Korea in nearly three decades.[89] The U.S. export controls may have led China to source fewer high-tech components from South Korea.[90]

Third, decoupling could also lead to a situation where American components are "designed out" of various products since many companies in the supply chain would not want to be subjected to constantly expanding U.S. export-control measures. A potential example could come from the Netherland's ASML Holding, the world's sole manufacturer of extreme ultraviolet (EUV) and deep ultraviolet (DUV) lithography machines, which are necessary to manufacture advanced chips. The United States has stalled the sale of the EUV machines to China[91] and is attempting to extend this prohibition to the slightly older DUV ones.[92]

This is significant since reliance on ASML's EUV machines is only expected to

deepen, due to the fact that each successive generation of chips has shrinking transistors that can only be packed onto a chip through, among other things, advances in lithography. The EUV machines comprise hundreds of thousands of components sourced from other suppliers. ASML produces only 15 percent of the EUV's components.[93] Among the suppliers for the rest is its subsidiary Cymer, which is located in the United States.[94] Considering the complexity of the EUV machines and the fact that it took nearly three decades to develop and commercialize them, Chinese buyers are very unlikely to be able to replace or replicate them in the short term. Reverse-engineering an EUV machine may not be a viable option since it is not a matter of merely accessing its blueprint and other technical data. The real asset of ASML is the technical know-how of the engineers who incorporate the thousands of components into an EUV machine. As argued by one observer, "the most crucial input into an EUV lithography system wasn't any individual component, but the company's own skill in supply chain management."[95]

However, given the criticality of semiconductors to the foundational technologies of tomorrow such as AI and robotics, China is unlikely to allow the denial of access to ASML's machines to stall progress in developing its own EUV/DUV machinery. Given its massive market for semiconductors, China might get non-American technology companies in the supply chain to replace American components with their own parts or to source components from another country. Meanwhile, in comments submitted to the BIS in November 2020, ASML stated that any effort to classify EUV machines as foundational technology and to subject them to export controls should only be done after taking into account the effect this may have "on the economy and the development of such technologies in the United States."[96] Given the vast number of American firms that supply ASML for its EUV machines, an attempt to block the company from selling to Chinese buyers may result in it sourcing from non-U.S. suppliers.

All of the above shows that technological decoupling is a part of the larger decoupling between China and the United States. Beyond the export controls, given the change in outlook regarding U.S. policies when it comes to various issues (such as investment screening, discouraging acquisitions by American enterprises in China, financial sanctions on Chinese companies for supporting security operations in Xinjiang, encouraging U.S. allies to ban Huawei from 5G networks, and visa restrictions), any change in the decoupling narrative will require addressing the key reasons underlying the shift in U.S. attitudes toward China. As mentioned above, the MIC 2025 plan was a wake-up call for not just the U.S. government, but also multinational companies all over the world that saw it as China doubling down on the use of massive subsidies, IP theft, and favoring its state-owned enterprises (SOEs)—precisely the issues that were raised by the U.S. trade representative in its 2018 report to Congress on China's WTO compliance. The prospect of reversing the trade war

will hinge on progress by China on the above issues. However, the reform picture for each of these issues does not look promising.

It is unlikely that China will end its subsidies. In fact, as mentioned, the export controls have reinvigorated its efforts to wean itself off American tech and it may direct more subsidies at critical technologies. Furthermore, since SOEs that receive many of these subsidies are national champions that have fueled the country's rise in many sectors, China is unlikely to change its playbook. For all their inefficiencies, SOEs have played a major role in spurring China's growth over decades and are unlikely to fall out of favor with the government. They are also a major mechanism through which "socialism with Chinese characteristics" is pursued.[97] Therefore, SOEs are likely to remain at the core of China's economic policies.

While China has made rapid strides in bolstering its overall competitiveness[98] and has shown that it can innovate,[99] its efforts to reduce IP theft are less impressive. There is still a high level of Chinese espionage, which is likely to continue, in part owing to the ambitious targets set forth in MIC 2025. Furthermore, China's industrial espionage system has reportedly developed into a "self-sustaining ecosystem" with many interest groups invested in seeing it succeed.[100]

Finally, it does not look like China will change its state-led or "authoritarian" capitalism model soon. Defending MIC 2025, which provides a roadmap for higher domestic market share for Chinese enterprises, Beijing's response was that the plan did not violate any WTO rules since it is transparent, indicative rather than mandatory, and in principle open to participation by foreign enterprises.[101]

From the above, the U.S.-China trade war is unlikely to cease. Within it, technological decoupling has become a battle to maintain control over sets of technologies. This is likely to spill over into the realm of standard setting. Semiconductors are uniquely positioned in the larger technology architecture since they power many advanced 5G technologies and applications. Leadership in 5G will therefore decide the shape of semiconductors usage. This leadership will depend not just on the technology and its applications powered by semiconductors, but also on whether a nation is deeply integrated into other facets as well, including standard setting.[102] Standards are especially significant from the perspective of the semiconductor industry, given the ever-increasing costs of manufacturing each new generation of chips. Economies of scale make chip manufacturing more cost-effective—mass production reduces the cost per unit for each semiconductor foundry. And mass production becomes easier if all components of chips are the same all over the world. Therefore, the question of whose standards will prevail is driving the next stage of the tech battle between China and the United States. Standards are also significant when it comes to the certification of chips. There are currently different efforts underway to ensure that common standards are developed for certifying the security, authenticity, and reliability of chips.[103]

Standard-Developing Organizations—The Next Battleground?

At a time when almost all major countries are seeking to build self-sufficiency in their supply chains, an excessive focus on doing so risks leading to inward-looking supply chains that may not interact with each other, or to supply chains in which different bubbles do not "talk" to each other and are not interoperable. This could lead to technologies that cannot be integrated and cannot function together. Accordingly, if there are different product specifications and distinct components that are not interoperable, the process of standard setting may be impacted the most by the technological decoupling.

Not having components with the desired functionality due to reasons of non-interoperability would hurt all industries that rely on semiconductors, since making the average semiconductor takes around 700 steps, not all of which are taken in one jurisdiction.[104] One would have to rely on creating one's own components since imports would not be an option from countries with noncompatible products. This would amount to de facto import substitution, which has its drawbacks as well.

To have the best chance of framing international technical standards, countries need two ingredients: standard essential patents (SEPs) that are of a certain qualitative threshold and influence within international standard-setting organizations.

The focus here is on the latter since that usually involves a direct role for governments, whereas SEPs are usually created by companies. The United States' approach to standard setting has been relatively laissez faire compared to that of countries in East Asia and Europe,[105] with the private sector playing a more important role. However, this approach may turn out to be naïve in today's hypercompetitive world. In its 2015 U.S. Standards Strategy, the American National Standards Institute stated that what hung in the balance was "the competitiveness of U.S. industry, the vitality of the U.S. economy, a balanced global trading system, and the health, safety, and well-being of citizens."[106] Despite its private-sector-led approach, the United States maintains a very dominant presence in international standard-setting bodies, with a recent study estimating that it held at least 50 percent of voting share in eleven of the thirty-nine organizations evaluated.[107]

China's approach, on the other hand, has been mostly state-driven. In the context of what some see as a neglect of international standard-setting organizations by the U.S. government, China has rushed in to fill the gap.[108] This focus is reflected in the saying in the country that "First class companies do standards, second-tier companies do technology, third-tier companies do products."[109] Beijing has also announced a China Standards 2035 initiative that seeks to wrest control of the process of setting international standards from Western nations.

Concerns about the Chinese approach to international standard setting have grown since there appears to be a tight relationship between the Chinese state and the Chinese companies that participate in standards development organizations (SDOs). This is exacerbated by simultaneous concerns about how nonstate businesses may also be influencing standards on behalf of China's government.[110]

However, observers of the standard-setting process point out that no amount of "stacking" of SDOs by a country can make up for a lack of technical credentials or market buy-in of the standard sought to be set.[111] Even if a country has a large population and a thriving ecosystem of technology companies, the government mandating certain standards locally and then hoping these will be adopted globally later does not usually work. For a start, the risk involved in adopting this path is immense. If its locally mandated standards are not adopted internationally, the country would be isolated from international norms and the trade that takes place in products that adhere to global standards. The scope for technical alienation is so high that any "local first, global later" plan may fail at start, a phenomenon called the Galapagos syndrome.

One example of this is a failed online authentication initiative of South Korea's government. The national Resident Registration Number (RRN), akin to the Social Security Number used in the United States, was used for accessing private and government services. The RRN was a unique identification number and was widely used for online identification. However, due to the possibility of data and privacy breach, the government proposed a new authentication system called the I-PIN (Internet Personal Identification Number). This was authenticated through measures like passwords complemented by CAPTCHA and installation of additional software to foil keylogging attempts. Following a severe data breach, the government mandated that the I-PIN should be renewed each year, in addition to requiring additional measures of authentication that posed great inconvenience to users. Due to the cumbersome process, the I-PIN initiative never really took off.[112]

This example shows that setting a standard through government fiat is insufficient and does not provide a significant first-mover advantage if the market does not consider it as commercially viable. Some even believe that the government-mandated initiative had a debilitating effect on the encryption industry in South Korea.[113] And, even if the I-PIN initiative had gained acceptance locally, getting acceptance as a global standard would have been far more challenging.

Experts have argued that China's strategy may not work smoothly since increasing its weight in standard-setting bodies is not enough to ensure a corresponding increase in the ability to sets global standards as these have to be approved by governments, companies, and engineers around the world.[114] However, this argument is reminiscent of an earlier assumption about China and the internet, which proved to be incorrect. The argument was once made that the internet would be a force for good and could not possibly be controlled or regulated by

China. The analogy employed was that cracking down on the internet would be "like trying to nail Jell-O to the wall," in former president Bill Clinton's words.[115] However, China has since had moderate success in instituting its Great Firewall, which has largely controlled or censored online conversations.[116]

China usually tries to benefit from the multilateral nature of institutions. Rather than act as a disruptor that completely disregards global cooperation and norms, it has used the current system to its advantage and acted as a "selective revisionist" power.[117] It prefers to work within existing international institutions rather than outside them, although it also aims to complement them with institutions in which it would have a greater say. The WTO and the World Bank have served China well in its ascension as a major economic power.[118] The country has shown no signs of abandoning institutions such as the UN, the World Health Organization, and the International Telecommunication Union (ITU); rather, it has sought to take key leadership roles in them.[119] Although China has set up institutions such as the National Development Bank and the Asian Infrastructure Investment Bank, these are largely supplementary initiatives and not meant to supplant global institutions such as the World Bank. Thus, China will not abandon international SDOs as it seeks dominance in setting global technological standards.

At the same time, China may seek to complement this approach with other measures in its standard-setting endeavors. This is where getting market buy-in may not be critical for it. For instance, the Belt and Road Initiative (BRI) is not just a massive infrastructure project but also another avenue to set standards.[120] While this principally concerns investment norms, the BRI also contains the imposition of technological standards. When Chinese firms like Huawei carry out telecommunication and infrastructure projects in BRI countries, they use Chinese standards. Through this China can set standards around the world. Once a critical mass of nations adopts standards, network effects may lead technology companies to decide to manufacture more products with Chinese standards as these would already have buy-in from users in various countries. Therefore, even without having the ones most broadly accepted or considered most viable at SDOs, China could still set standards. This would not be unprecedented. In the 1980s, while American companies were trying to position their cellular phone technology as the de facto standard by having an enormous domestic base of users, European companies came together to advance a single standard for digital cellular phones. The latter focused on securing a higher number of users worldwide and won the battle for setting the standard.[121]

Therefore, though China has had its fair share of technologies afflicted by the Galapagos syndrome,[122] its recent gambit at setting international standards might pay off. If all enterprises and users across a region use the same standard, this will create lock-in effects. As noted above, setting standards is as much about geopolitical aims as identifying the best technical standard.

Bloc by Bloc: Where Do India and Others Stand?

With a decoupling between China and the United States underway, there is a question as to where others will fit in. The answer is of increasing relevance to semiconductor companies that are situated at different stages of the supply chain in various parts of the world.

Some have argued that any alternative vision to the collaboration witnessed in the previous decades would probably be a world where a lack of international exchange leads to reduced innovation. It is said that this is the real threat that a U.S.-China decoupling presents to the global innovation ecosystem.[123]

This can be rebutted, however, on three grounds. First, this view assumes that innovation is contingent on global collaboration. Second, a corollary of this view is that fragmentation of tech ecosystems may lead to stagnation of innovation throughout the world. Third, the state of innovation may not be a priority for most nations, which might be willing to make a tradeoff in favor of secure, trusted supply chains as opposed to current ones where chokepoints are controlled by adversaries. As it is, even though globalization components are sourced from all over the world, the technology to build semiconductors has not diffused.[124] It is still handled, controlled, and perhaps even dominated by a few companies.[125] These three points, elaborated below, show how concerns about technological decoupling possibly blunting innovation may not be justified. In that case, nations will be less concerned about technological decoupling and may be more interested in leveraging it in deciding which tech bloc to align themselves with.

First, governments the world over use various means to promote innovation. These include trade policy and international connectedness, and policies that focus on property rights, education, R&D subsidies, and proliferating research universities. However, there is no one policy that determines whether innovation will thrive in a country—the country must perform well in each one.[126] Similarly, the relative weight attributed to a factor like trade policy is the weakest among all those means. Thus, for example, while the United States had strong antitrust enforcement, smaller firms, and a more open economy, the insular Soviet Union out-innovated it in cutting-edge areas like space technology for a while, and Japan innovated rapidly despite having "tight government control over trade and investment, cooperative industry-labor relations, and specific corporate management techniques."[127] Therefore, it cannot be said with certainty that global collaboration is a singular factor promoting innovation.

Second, fragmentation of tech ecosystems does not always lead to stagnation in innovation, as the case of China's space sector shows. In 2011, the U.S. Congress passed a law—known as the Wolf Amendment—prohibiting cooperation between the National Aeronautics and Space Administration and China's space program, on grounds of human rights violations by China. However, the consensus, including among many in the United States, is that the Wolf Amendment has hastened space-tech innovation in China and has been of limited utility in persuading U.S. allies to curb their space cooperation activities with the country.[128] In 2021, the vice chief of space operations for the U.S. Space Force stated that China was developing its space capabilities at twice the rate of the United States.[129]

Third, even though there is a view that the prospect of a shortage of semiconductors may be overblown,[130] countries have woken up to the fact that chokepoints in supply chains constitute a pressing concern. Accordingly, resilient supply chains are now seen as just as important as efficient ones.

Owing to these three reasons, technological decoupling may be here to stay for the foreseeable future. In such a scenario, others could align themselves with China or the United States, or they could try to remain in a neutral position. Their choice is likely to be determined by a mix of factors:

- The financial cost of adopting U.S. or Chinese tech infrastructure, with the choice of a 5G vendor likely to be a good indicator
- The trust in such tech infrastructure
- Which bloc will deliver more benefits in terms of development priorities
- Congruence or incongruence on "values"

The actors assessed in Table 1 represent critical nodes of the semiconductor global supply chain. The EU is the sole purveyor of EUV machines and houses cutting-edge design capabilities for chips. Japan is reviving its efforts to pursue cutting-edge semiconductor manufacturing, having been a powerhouse in this field in the 1980s.[131] It is also increasingly becoming a base for supplying advanced semiconductor manufacturing materials such as silicon wafers and chemicals, with a global market share estimated at 60 percent.[132] South Korea—the base for Samsung, one of the few integrated device manufacturers still competing vigorously in the international market—is one of the nerve centers of semiconductor manufacturing, and the collective decisions of its companies will have a vital bearing on the debate over China-centric or U.S.-centric supply chains. Indonesia, a major car-manufacturing country, is seeking to onshore semiconductor production. It is actively positioning itself to take advantage of the semiconductor supply chain movement out of China.[133]

Table 1. Where do key regions stand on different aspects of semiconductor technology?

	Cost	Trust/Security	Development	Values
EU	The total cost of deployment of 5G networks across the EU is estimated at €400 billion. However, the EU has recognized that, while restricting participation by "a key vendor" may increase 5G infrastructure costs, replacing and upgrading "high-risk" Chinese vendors may entail higher costs.	The European Parliament has noted that Chinese technology is widely believed to be plagued by cybersecurity issues.[134] China's 2017 National Intelligence Law has not helped that perception,[135] with its Article 7 compelling all Chinese enterprises to assist the state in national security work.[136]	While the EU is more aligned with the United States, it does envision its own technological stack. European Commissioner for Internal Market Thierry Breton has said that the EU must act more like a "strategist" than a market. It should make its choices and draw up its rules, and it should not be afraid of imposing them on its partners.[137] European Commission President Ursula von der Leyen has said that Europe "must have mastery and ownership of key technologies."[138]	The European Court of Auditors has found that, compared with 5G vendors from other countries, Huawei and ZTE fared poorly, owing to the fact that China scored low on factors such as recourse to the rule of law, judicial independence, and adequacy of data-protection regime.[139] The March 2019 communication of the European Commission to the European Council stated: "There is a growing appreciation in Europe that the balance of challenges and opportunities presented by China has shifted."[140] It also labeled China as "an economic competitor in the pursuit of technological leadership, and a systemic rival promoting alternative models of governance."
Japan	The top two Japanese mobile carriers are expected to spend around $38 billion on 5G networks in the 2020s.[141] The tensions between China and the United States present an opportunity to Japanese firms such as NEC and Fujitsu to enter the fray as well, even though their collective market share is minimal.[142]	Japan has committed to participating in the U.S.-led Clean Network Initiative, which aims to procure telecommunication equipment only from trusted vendors.[143]	NEC and Fujitsu are collaborating on the Open RAN model, which is distinct from the current model used by Huawei where only one company provides hardware and software for 5G networks. The U.S. government has played a critical role in ensuring that Japanese firms are part of the Open RAN coalition.[144]	As a treaty ally of the United States and a member of the Quad grouping, Japan will almost certainly not align itself with the values espoused by China.

	Cost	Trust/Security	Development	Values
South Korea	Since Samsung is a major player in the semiconductor industry, South Korea will likely look to source tech locally. However, extricating itself completely from China would have an impact. China still accounts for approximately $60 billion worth of South Korean semiconductor demand.[145] Foregoing this and making up for it in the short term would be a challenge with financial implications.	During President Joe Biden's visit to South Korea in May 2022, his first stop was to a Samsung electronics plant. During the visit, South Korea and the United States released a joint statement stressing not just working together in semiconductors but also considering alignment of their export-control mechanisms related to such critical technologies.[146]	South Korea has traditionally viewed the United States as a security provider and benefactor. This is unlikely to change anytime soon.[147] The merging of national security concerns and semiconductor supply chains further complicates things for South Korea.	South Korea walks a strategic tightrope in balancing its relations with China and the United States. However, its cooperation with the United States has been undergirded by common values. South Korea has joined the Chip 4 Alliance, a U.S.-guided semiconductor-focused alliance in East Asia that seeks to coordinate policies in this field. While South Korea is keen not to be seen as picking sides,[148] it has so far committed to partnering with the United States in semiconductor supply chains.
Indonesia	China's advantage appears to be two-fold with regard to Indonesia. First, its telecom equipment is cheaper. Second, since 2007 Chinese state-owned banks have provided up to $600 million in financial assistance to Indonesian buyers, which may have been used to finance the purchase of Huawei's products.[149]	Indonesia's view is that using Chinese equipment would not necessarily compromise its cybersecurity in a unique way since most vendors—whether from Japan, South Korea, or other U.S. allies—present an espionage risk.[150]	Chinese companies such as ZTE and Huawei know that Indonesia places a high priority on its digital development, given how in 2018 the World Bank found that it could face a shortage of approximately 9 million ICT workers by 2030. Chinese tech companies have thus launched capacity-building programs for Indonesian engineers and train government officials in cybersecurity.	While Indonesians' trust in China has fallen sharply,[151] Chinese tech companies are seen as more cost-effective and better contributors to national development, which means that "values" are unlikely to play a major role when it comes to aligning with any tech bloc.

Where Is India Likely to Position Itself?

Regarding China, India has adopted a series of measures in the wake of the Galwan valley border skirmish between the two countries in May 2020. These have arguably reversed the impressive inroads that Chinese manufacturers had made into India's electronics market over the years.[152] For the first time, India has linked the resolution of its long-standing border dispute with China with progress on other aspects of its relationship with the country.[153] This has come at the expense of commercial ties. In April 2020, India had already unveiled measures aimed at "curbing opportunistic acquisitions of Indian companies" by entities

belonging to a country that it shares a land border with.[154] In June 2020, it moved quickly to ban scores of Chinese apps.[155] In May 2021, India announced that it had cleared its mobile carriers to carry out 5G trials using equipment from companies such as Ericsson, Nokia, and Samsung, with Huawei a notable omission. India explained that it had excluded the Chinese company because of its inability to comply with the security directive for supply of network equipment.[156] India abandoned any ambiguity regarding its stance on using Chinese network equipment and, by extension, its view of Chinese technology.

India, for now, seems keen to hedge its bets and to adopt an approach that favors multiple partnerships. Its external affairs minister has stated that the changing U.S.-China dynamic, will provide opportunities to be exploited in a manner that advance India's national interests.[157] However, he added that India would "grow with others, not separately," and that this would require partnerships with nations that have similar "values," which would matter "even more so in a technology-driven world."[158] Given these statements and the recent measures aimed at Chinese companies, India seems to be more open to aligning with a U.S.-led bloc, which would be reflected in where it stands in discussion on the semiconductor global supply chain.

Overall, India's semiconductor policy is seen by the press as a bold bet on entering the global value chain at various levels of the supply chain,[159] be it manufacturing, chip design, or assembly and packaging. The fact that the government amended its semiconductor policy in October 2022 to streamline the amount of subsidy given to manufacturing of mature nodes and to align it with the subsidy given to more leading-edge nodes shows quick iteration and a desire to listen to stakeholders in the ecosystem. That said, India could do some things in the short term to enhance the effectiveness of its semiconductor policies:

Financing: Currently, only a disbursal of the committed amount by the Indian Semiconductor Mission (ISM), the nodal agency for screening investments in the semiconductor sector, will be undertaken. The amount will be released based on the terms of approval by the ISM. However, there is no provision for loan guarantees, which are usually seen as having a multiplier effect in terms of allowing the debtor to raise more money. These could be considered.

Reimbursement basis financing: Currently, in the Design-Linked Incentive (DLI) scheme, it appears that the companies will receive the amount only on a reimbursement basis. This means that no upfront money will be given to startups. The amount will only be reimbursed based on achieving certain milestones. There is no provision for claw-back.

Spin-offs not mentioned in any scheme: In order to make it easier for the DLI scheme to be self-sufficient in terms of financing, there should be a provision for the Center for Development of Advanced Computing, its nodal agency, to acquire equity in the recipient company. The Industrial Technology Research Institute in Taiwan did this during the time it incubated TSMC and other semiconductor companies.

What happens when the 15 crore rupees ($2 million) committed dries up? Venture capital funds need to be able to see that the technology in question is ready to be commercialized. It is unclear whether they will step in to do so once government funding dries up. Sometimes, the cost of creating advanced chip designs is in excess of $100 million for a leading-edge chip.[160]

ISM expertise: The ISM does not appear to be part of any interagency collaboration. It is housed under the Ministry of Electronics and Information Technology and does not have the same linkages with ministries enjoyed by the United States' CHIPS Program Office, which has connections with the departments of defense, state, and homeland security among others.

The Story So Far

India aspires to be a key player in the tech ecosystem in its own right, and it realizes that this will require "delivering at home" before it can "lead abroad."[161] Developing its own tech stack would benefit India when taking into account the factors of cost, trust, development objectives, and values discussed above. India's recent attempts to incubate its own 5G network equipment ecosystem of domestic vendors is an example of it developing local capabilities first. In August 2018, the Telecom Regulatory Authority of India released recommendations to encourage domestic manufacturing of telecom equipment.[162] While this was motivated more by the need to reduce costly imports, it incentivized major conglomerates like Reliance to start developing an indigenous 5G network management system.[163] India is no stranger to building tech products that may have global applications. It has an impressive roster of digital technologies that it has deployed in the field of digital payments and digital identities software, and which it is seeking to promote abroad. However, software is very different from hardware, such as semiconductors. Software products have fewer entry barriers and can pivot to new opportunities relatively easier because of their digital nature.[164] India remains a huge net importer of hardware technology.[165] This will continue as hard-tech innovation usually takes a generation or two to come through and requires substantive changes in a country's science and technology research ecosystem.[166]

India's best bet in the short term remains closer integration with nations possessing similar values that are also key players in the semiconductor supply chain. This has recently been labeled as "friend-shoring," a term that describes a select group of nations banding together and supposedly limiting "the trade of key inputs to trusted countries in order to reduce risks to the supply chains."[167] The concerns voiced about "friend-shoring" range from protectionist lobbies using it to restrict competition to oligopolies emerging. However, these can be addressed by rules that regulate lobbying and antitrust laws. In addition, suggestions that using supply chains as they existed before the U.S.-China trade war will help create economic interdependencies among nations and thus lessen the prospect of war are misplaced.[168] For instance, China's thriving trade with Japan or with South Korea has a number of times been affected by national security clashes.

In the long term, India would likely seek a larger role in the semiconductor supply chain. This can be seen from its bets in other technological spheres, such as in 5G where it seeks to promote indigenous technologies and global standards. India did have success in proposing a local 5G standard, dubbed 5Gi, which was approved as a standard/technology specification by the ITU in November 2020.[169] 5Gi reportedly went through a thorough vetting process for over three years before being approved. Its unique selling point was that it substantially enhanced base station coverage without massive capital expenditure. However, there was significant opposition to 5Gi from certain telecom vendors and the Cellular Operators Association of India that argued India should seek to adopt global standards rather than standards yet to be harmonized with global ones. While this was rebutted by experts from institutions such as the Indian Institutes of Technology who argued that compatibility between the ITU-approved 5Gi and the 3GPP 5G standard is possible without compromising on interoperability, the 5Gi standard was eventually merged with the 3GPP 5G one as a compromise between the cellular industry and domestic standards organizations such as the Telecom Standards Development Society, India.

This disagreement between stakeholders delayed the 5G rollout in the country. The Lok Sabha's Standing Committee on Communications and Information Technology noted the concerns that there is a real danger that going alone in the standards process would risk scenarios where the country is stranded in terms of harmony with global standards.[170] The committee wrote:

> Considering that similar efforts in the past by other countries like China, Korea, etc. have been failures due to the lack of harmonization of these standards with the global ecosystem, the Committee would want the Department to be extra careful before adopting such standards in the country. The Committee recommend that the Department should look into the concerns raised by [the Cellular Operators Association of India] and TSPs [telecom service providers] and ensure that their concerns are adequately addressed. While emphasizing that India should adopt the standards that are good for the country, the Committee also desire that the Department should also take into consideration the interests of all before taking the final decision and adopt standards that will be in the best interest of the country.

Therefore, while the 5Gi standard was technically sound and the result of a carefully reached deliberative process, it lacking an international presence was the most likely factor in it not being adopted. This highlights the need for India to dwell on a carefully thought-out strategy prior to pressing its case in international forums since, despite the ITU approving the 5Gi standard, it clearly did not have international buy-in, as well as from telecom services providers, and was yet to be harmonized with international standards.

Setting standards is key in the realm of semiconductors. India's significant presence in the design stage of the semiconductor value chain (albeit through subsidiaries of foreign firms at the moment) is at odds with the marginal role it plays in setting global standards. India's

tech is largely seen as being "clean" and does not seem to have any backdoors, a criticism often leveled at technology from China.[171] This could help promote Indian tech internationally. The U.S. National Security Commission on Artificial Intelligence has highlighted that the United States could lead an emerging tech coalition of "like-minded countries" to push for standards in AI by following the model of the U.S.-India Strategic Tech Alliance.[172]

The worsening of the technological war between China and the United States has spillover effects in standards setting. With both keen to promote their respective standards, others may become ensnared into choosing between a China-led bloc and U.S.-led one. India seems keen to hedge its bets and to focus on developing partnerships with a wide range of countries in the supply chain, while at the same time maintaining a strong focus on shoring up its capabilities in the semiconductor ecosystem.

Conclusion

The geopolitics of the semiconductor supply chain has undergone a rapid shift with the introduction of export-control measures by the United States. Semiconductors were not initially entangled with the larger issues driving the U.S.-China trade war. However, the U.S. Department of Commerce placing Huawei on its Restricted Entity List in 2019 meant that a new rationale grounded in maintaining its technological superiority was introduced by the United States. Given that U.S. export-control measures have been applied alongside tariffs introduced by China and the United States, a decoupling of their economies is underway. This decoupling has accelerated with other restrictions introduced by the Trump and Biden administrations regarding investment screening and visas.

Outcomes that may result from the export-control measures include a stoking of China's efforts to wean itself off U.S.-controlled chokepoints in the supply chain, a possible "designing-out" of American components in some semiconductor manufacturing equipment, and unintended consequences in the form of short-term costs being inflicted on American semiconductor companies.

Given the geopolitical nature of the U.S.-China battle to secure key chokepoints in the semiconductor supply chain, semiconductor companies will be looking to reconcile these different outcomes to ensure that their supply chains do not have to be significantly recalibrated. The provisions in the U.S. Chips and Science Act that permit the production of "mature" node semiconductors in China is a case in point. Semiconductor companies will

also be evaluating coalitions of like-minded nations that may band together to ensure that a seamless supply chain can operate. In this regard, it will be interesting to see how India's efforts as a part of the Quad's Semiconductor Supply Chain Initiative, which is still short on details, will play out.

In the long term, India is likely to introduce policies that help attract some semiconductor manufacturing and design capabilities to the country, especially if the hollowing of China's semiconductor industrial base continues to take place. The U.S. export-control measures have, for the moment, gutted China's semiconductor industry, but that has only expedited Beijing's movement toward developing its indigenous technology infrastructure. How these efforts to shape semiconductor supply chains evolve will be one of the defining trends of the twenty-first century.

About the Author

Konark Bhandari is an associate fellow with Carnegie India, and a lawyer who has researched on certain areas in the digital economy, focusing primarily on approaches to anti-trust regulation of companies in the digital realm. He had earlier worked at India's antitrust regulator—the Competition Commission of India (CCI)—where he worked closely with senior officials on a variety of matters. He is also an avid follower of the regulation of space technology ecosystem and is keen to contribute to that discipline.

Notes

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